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Agricultural Transportation Challenges of the 21st Century

Long-Term Structural Shifts in Grain, Oilseed, and Animal Industries in the United States

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During the past 20 years, the changes in U.S. agriculture have been profound, yet more will occur over the next 20. Where is the industry headed? What will the food system look like? What are the implications for the transportation industry that serves agriculture? Is current transportation policy in harmony with the future?

While the future cannot be accurately foretold, this paper will provide insights into the changes of the past 20 years and the factors that have driven them. It will identify how those drivers may evolve and extrapolate, with analysis and judgement, the important impacts projected to 2020.

The goal of the project is to provide a 2020 baseline from which the transportation industry, policymakers, and other analysts can discuss key findings and implications. It is through such discussions and future analysis that the transportation industry and transportation policy can most efficiently align in the direction of coming changes.

Major Drivers and Trends to 2020

The drivers of change from now until the year 2020 will determine the shape of world agriculture and, therefore, the need for transportation services. Those drivers can be categorized as follows:

- Economics—including population, incomes, and consumer preferences
- Technology—traditional, biotechnology, and information technology
- Industrialization—issues of specialization, consolidation, and coordination
- Globalization—involving increased trade, regional specialization, international ownership, and coordination
- Environment and consumer attitudes—environmental consequences of the way agriculture is organized and the attitudes of citizens regarding such concerns as biotechnology, animal-human conflicts, animal rights, and animal welfare

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- U.S. domestic and foreign policies--including agricultural and economic policy

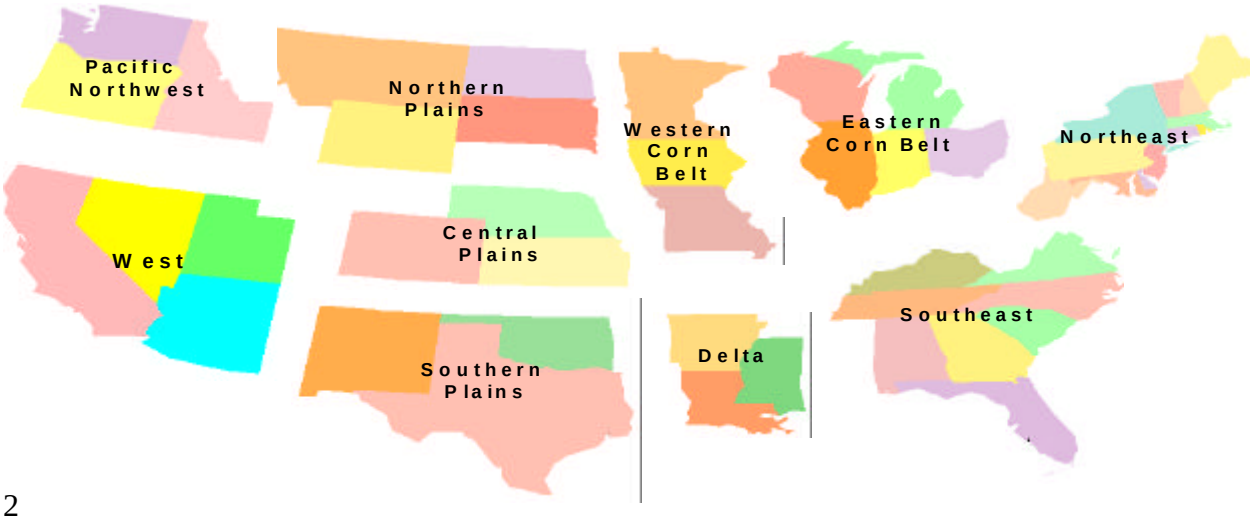
Each of these drivers will have major impacts on transportation needs, so the direction of each will be evaluated.

Economic Drivers–Population – Population is a major driver of food demand. While subject to error, population forecasts are likely the most accurate of the forecasts in this analysis. The world will feed an increased population, but the rate of increase in people relative to food production will influence diets as well as the cost of food.

World population increased from 4.5 billion in 1980 to 6.1 billion in 2000, an average annual rate of 1.56 percent. The U.S. Census Bureau estimates a further increase to 7.5 billion in 2020, an average annual rate of 1.07 percent (with the rate of increase decreasing to 0.9 percent by 2019. Population change is far from uniform around the world. United Nations estimates of increases from 1995 to 2020, reported by Pinstrup-Andersen, Pandya-Lorch, and Rosengrant, range from 3.8 percent for developed countries to 70.3 percent for Africa. Developing countries will account for 97.5 percent of the projected change in world population. Asia, excluding Japan, accounts for 61 percent and China, alone, for 13 percent. In addition, the urban population of developing countries is expected to exceed rural population before 2020.

The U.S. population increased 20.4 percent from 1980 to 2000, an average annual rate of 0.96 percent. Current projections indicate a 17.5-percent increase (.8 percent annually) from 2000 to 2020. Figure 1 shows regions of the country that will be referenced throughout the study. Growth is expected to be highest in the West (35 percent), Pacific Northwest (29 percent), Southern Plains (28 percent), and the Southeast (21 percent). These four regions are expected to account for 74 percent of total growth. The slowest growing will be the Western Corn Belt (11 percent), the Northeast (9 percent), and the Eastern Corn Belt (6 percent) (Campbell, 1997). Population location defines the location of final demand for food and influences the location of agricultural production and processing.

Figure 1: Study regions of the United States



Economic Drivers–Income – For most of the world's population, income severely limits diet, both in quantity and composition. Analysts are generally optimistic with respect to income growth for most of the world's people. There is reason to expect Russia and other lagging economies of the former Soviet Union to begin to grow again as several have already begun to do so. China's growth has been impressive following reorganization of incentives and opening to trade. Pinstrup-Andersen, et al. project 1995-2020 world annual income growth of 2.6 percent with the most rapid rate of increase in developing countries at 4.3 percent per year. Food demand, both in quantity and composition, in the developing world is shaped primarily by population and income. Increasing per capita income will induce a shift from cereals to meat and dairy products.

The United States Department of Agriculture (USDA) baseline projections show real U.S. Gross Domestic Product (GDP) growth at an average rate of 2.5 percent. The Food and Agricultural Policy Institute's (FAPRI) baseline income estimates are slightly higher for both the United States and the world. Low-income elasticities for food consumption in developed countries suggest modest impacts on the volume of food used, but a shift toward more highly processed food products is likely. Health, variety, convenience, and other attributes such the natural and ethical treatment of animals outweigh income and price in shaping diets. There is a limit to the quantity of food used per capita (although U.S. use now exceeds what many perceived as the limit a few years ago). As stated by Pinstrup-Andersen et al., "almost all of the increase in world food consumption will take place in the developing countries." A shift toward the consumption of more animal products in the developing countries will propel increased use of grains and proteins for feed.

Production Technology – It is the biotechnology era. Consumer reaction has slowed the process, but transgenic modification of crops is underway, and animal breeding will not be far behind. So far, most of the innovation has benefitted the cost side that is appreciated by the producer, not the consumer. Consumers accept the "biotech" process in medicine where the benefits are dramatic and affect them directly. Genetically modified organisms (GMO) are also being used in food processing without serious objection. Genetic innovation that provides demonstrable health benefits, such as human disease prevention or enhanced nutrition, can pave the way for acceptance.

It is impossible to forecast the impact of these, as yet unknown, innovations. Two aspects of change that might be accelerated by transgenics are crop adaptation and composition. The first could have significant impact on production location. For example, conventional breeding has already expanded the area feasible for soybean production. The second may affect the relative use of grains and oilseeds. Altered composition of crops for special uses, whether by conventional breeding or transgenics, probably means increasing nonmarket coordination of animal production, crop production, and processing as well as growth of identity-preserved transportation and handling.

Genetic progress, transgenic or traditional, can be expected to increase crop yields and lower unit

input use. Regression analysis indicates the annual rates of yield increase from 1980 to 1999 to be .7 percent for wheat, 1.6 percent for corn, and 1.7 percent for soybeans. Biotechnology presents the possibility that these rates might increase considerably. However, in this study, yield increases to 2020 were based upon historical yield trends; biotechnology is expected to contribute toward maintaining those rates.

Progress in animal systems will continue in nutrition, genetics, and production techniques, as well as in increased coordination throughout the chain. Large confined feeding units have not gained public acceptance from the standpoints of animal welfare and waste handling. Policy at the State and local levels will have a major impact on the location of production and production practices. Restrictions on production processes will slow the rate of productivity change. Environmental cost will increasingly be recognized, with public policy forcing external costs to be internalized at the production level. Modification of crop composition for specific animal uses, if it happens, will encourage the geographic ties of crop and livestock production. More complete control of the animal housing environment will reduce the influence of climate on location of animal production, causing some shifts in feeding locations.

Processing Technology – Changing technologies that will affect the product mix and location of agricultural production include reduction of labor required, extended shelf life of foods, production of more ready-to-eat products, and increased genetic ability to modify the raw products. The direction of influence varies. Processing labor availability and cost have been factors influencing the location of processing and, in some cases, of production. For example, labor cost and availability has been a significant factor in determining the location of broiler production and processing. Reductions of labor required in poultry processing will reduce the ties to traditional areas. Improved control of microorganisms, including irradiation, and packaging innovations to extend the shelf life of processed foods reduce ties to consumer location. On the other hand, extension of processing to the ready-to-eat level suggests a more consumer-oriented location for some products, but growth of frozen products shifts processing in the direction of production. The ability to manufacture food products by modifying or recombining more basic components of raw materials such as proteins points toward less reliance on specific-attribute crops or animals. Under this scenario, biotechnology will likely play a major role, favoring commodity production rather than encouraging specific attribute raw products. Thus, the question of whether processing shifts more to raw material supply or toward the consumer is mixed but likely favors raw material locations.

Promise of Information Technology –Information technology affects both within-firm and market-level relationships. More effective internal controls may favor integration or nonmarket coordination. Information technology also should move agriculture toward frictionless exchange of both goods and transport services. Reduction of transaction costs facilitates specialization of firms using market coordination. That is, reduced transaction costs reduce the incentive to integrate commodity production and processing. Likewise, improved information exchange should reduce cross hauling and empty back hauls. Information systems (and markets) will also need to carry and evaluate much larger amounts of information. As an example, an increase in specific attribute production increases the need for information exchange, including information

about volumes, price, location, and special attributes. While these issues will require more sophisticated information systems, development of these systems can make markets more transparent, thus reducing costs. Markets for contracts and forward delivery for specialty products can be made more transparent and efficient, promoting a competitive structure, or information can become more proprietary, making markets less competitive.

Integration of commodity and transport markets should also be feasible soon. For example, it is now technically feasible to trade goods using an Internet-based trading system that would include rematching of trades during a specific period of time, such as each day. At the end of the day, all transactions within a given geographic area for a commodity, such as number 2 yellow corn, could be rematched to minimize transportation costs. The savings from this system could then be reallocated to users.

Industrialization and More Concentration – One of the major drivers of change in world agriculture over the past 20 years has been the application of industrial principles to agricultural production. The study defines industrialization as the movement to large-scale standardized production units often tied to input supplies and product markets through nonmarket coordination mechanisms such as contracting. While the industrial revolution occurred in the first half of the 19th century, those principles were largely only applied to agriculture during the last half of the 20th century. For animal agriculture, the application of industrial principles was retarded by the inability to control diseases in large animal concentrations. Poultry was the first to industrialize in the 1950's and 1960's. Cattle feeding was next in the 1960's and 1970's. Hogs and dairy followed in the 1990's and early 2000's. Cropping agriculture, on the other hand, was in a secular trend toward a more industrialized sector for much of the 20th century but was slowed in comparison to animal agriculture by a host of factors, including land tenure, policy that has attempted to support small farms, and rural tradition.

Several consequences are important to transportation issues. Concentration in the number of producers tends to be rapid for animal industries and slower for grains and oilseeds. Fewer producers result in concentration of input suppliers, product market locations, and processors as well. Coordination between raw material suppliers and processors increases, and production/processing centers result. For animal agriculture, geographic concentration occurs in both production and processing.

Industrialization also means movement away from diversified grain/livestock farms to more specialized farms. Grains and feedstuffs that were once fed on farm may now be produced under contract for a local large industrialized animal production operation. Alternatively, in the case of poultry, dairy, and hogs, the growth of industrialized production has occurred in locations distant from the primary crop production base. This means that large transportation demands have arisen, such as the movement of Corn Belt grain to the Southeast poultry and hog markets or to West Coast dairies.

For crops, an increasing portion of transportation demands are concentrated around large industrialized animal units or grain-processing facilities. Economies of scale have made it

advantageous to build huge processing or feeding facilities with truck or rail shipments from greater distances. On the output side, these concentrated centers have large transportation needs for product shipments. Highly concentrated industries have huge transportation needs in their immediate area but little between these production/processing centers (this is especially true for animal agriculture).

In determining the location for industrialized animal production, there is some flexibility. This decision is often driven, not only by the lowest costs of production, but also by environmental restrictions and local citizens' acceptance of industrialized animal agriculture. For grains, initial processing often occurs near the grain production.

Globalization and Increasing Trade – The world is moving in the direction of reduced trade barriers and increased trade. The North American Free Trade Agreement (NAFTA), the General Agreement on Tariffs and Trade (GATT), and the World Trade Organization (WTO) are foundations for this movement, and increased openness of China is an example of its success. Yet, progress is slow. While the world economy has much to gain from increased trade, each country has sectors which face decline as well as sectors that will benefit. Owners of assets in declining industries and their employees seek political protection for their investments and their jobs, and politicians often accommodate. Thus, just as in recent rounds of GATT, progress will be slow and incremental rather than revolutionary.

Thinking globally changes many dimensions. Capital and technology will move more freely across borders. Each region will see greater specialization in business activity based upon resource endowments, political and economic stability, and absolute and comparative economic advantages. Exploitation of economies of scale can be exercised in larger markets with the potential of ever larger regional concentrations. Business functions will be increasingly globalized. For example, input supplies may come from one country with production in another country for distribution to additional countries. Meanwhile, financing could be arranged in still a different country with risk management and overall coordination in yet another country.

Many resources already move across the globe in nearly seamless fashion, such as capital, management coordination, ideas, concepts, and communications. Those resources that can move nearly seamlessly can be globalized most rapidly, as demonstrated by capital flows and Internet activity. However, movement of physical products still involves transportation services, and, therefore, globalization will occur at a slower pace. This means that increased efficiency and cost reduction in global transportation will be vital components in the ability of the world to reach its economic growth potential through greater trade. Trade within North America is already forcing diverse countries to harmonize their transportation regulations, and even more integration of transportation policies will be required, both on this continent and worldwide.

Environmental and Social Concerns – The future of U.S. and world agriculture will be molded by issues of environmental and social concerns regarding how agriculture is organized. These include impacts of agriculture on the air, water, and land use, as well as a long list of social concerns including the impact of biotechnology products, plus animal welfare and animal rights.

Locations of animal production have already been greatly influenced by these factors. Conflicts between residential/recreational use versus agricultural land use will grow. By 2020, these concerns may even alter the balance of how much food production occurs domestically and how much is produced in other countries and then imported.

Science and technology are the best hope for finding solutions that enable agriculture and people to reside together. If conflicts cannot be reduced, agriculture will be increasingly concentrated into sparsely populated areas or to foreign countries. For the 2020 analysis, it is assumed that science will find acceptable solutions and that U.S. food consumption will be dominated by that from domestic production.

U.S. and Foreign Policy Uncertainties – Decisions regarding agriculture policy will be critical to the future of agriculture in this country and worldwide. U.S. decisions regarding governmental acreage management as well as the form and level of farm income supports will be strong drivers. These same issues face each of the developed nations, such as Japan, and the European Union, which is facing introduction of potentially highly productive Eastern European countries into the Union. A key driver in this area will be the evolution of China's agriculture and general developmental policy. Will Chinese consumption of food be allowed to rise faster than its food production capacity, as many now believe? Other major influences include the level of investments other world producers will make in research and development for their agriculture industries and the level of infrastructure investments that occur in such areas as transportation services, as currently demonstrated by Brazilian investments in river transportation improvement.

The baseline used in the study for changes in transportation needs until the year 2020 also depend on U.S. policy direction. We assume continuation of the essence of the Federal Agriculture Improvement and Reform (FAIR) Act (a.k.a. the "Freedom to Farm Act"), a full production policy except for the Conservation Reserve Program (CRP) is assumed. A return to price supports with acreage controls would encourage other countries to increase production at the expense of U.S. exports and associated transportation services.

Crop Perspective 1980 to 2020

Farm Structure – Between 1980 and 1999, the number of U.S. farms declined by 10 percent. There is, however, a contrast in regions. In terms of percentage changes, the largest decreases were in the Eastern Corn Belt and the Delta, where farm numbers were reduced by about 20 percent. Western Corn Belt and Southeast farm numbers were down 16 percent, about 10 percent in the Central and Northern Plains and the Northeast. Farm numbers increased in the Southern Plains, the West, and the Pacific Northwest.

Average farm size increased the most in the Corn Belt regions, about 16 percent on average. Smaller increases in average size of about 6 percent occurred in the Northern and Central Plains. Farm size decreased in the West (26 percent), the Pacific Northwest (15 percent), and the Southern Plains (17 percent). These decreases are related to the increase in farm numbers in those regions.

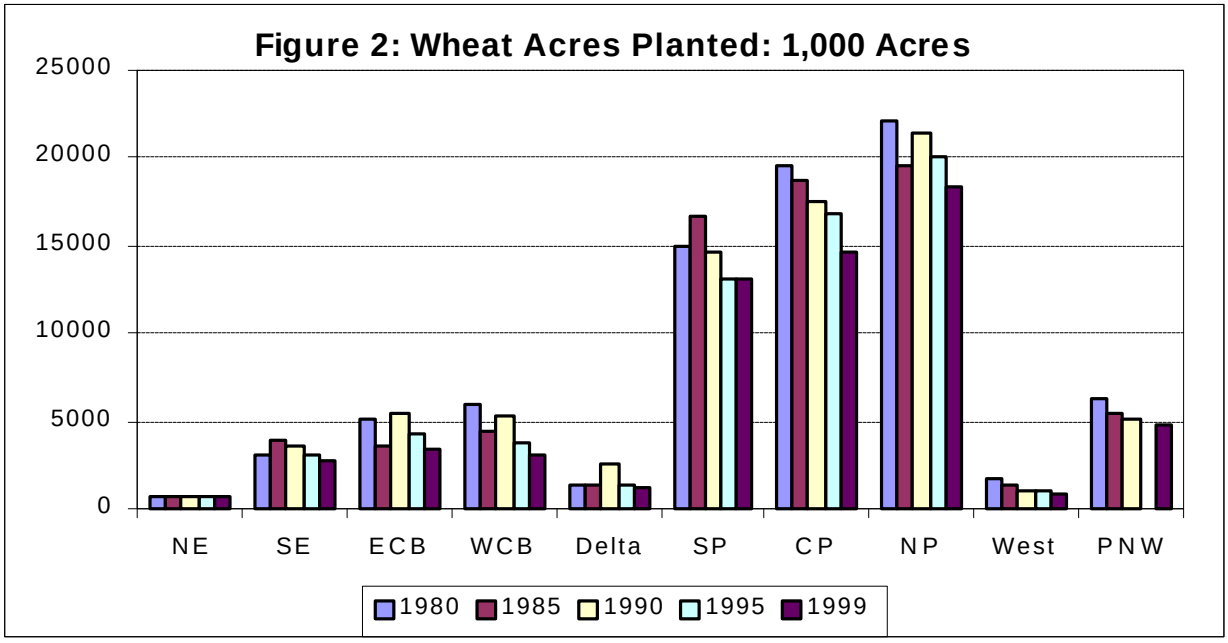
Due to the inclusive definition of "farming," these numbers do not provide a valid picture of commercial farming. As an example, the 1997 Census of Agriculture shows that 50 percent of the 2.2 million farm operators listed their primary occupation as something other than farming. Even more telling, however, is that the largest 3.6 percent of the farms accounted for 57 percent of agricultural receipts, and the largest 8.2 percent accounted for 72 percent. This means that only 180,000 farms were accounting for nearly three-fourths of agricultural sales. By 2020, that number could easily be reduced to fewer than 100,000 farm locations contributing the vast majority of agricultural output.

Table 1: Change in planted acres, major crops, 1999-1980 and 2000 CRP (1,000 acres)

Region/grain	Corn	Soybeans	Wheat	Sorghum	Cotton	Change 1980-99	CRP 2000
Northeast	-971	280	51	-14	0	-654	185
Southeast	-4,162	-8,245	-221	-346	-3,053	-9.921	1,674
Eastern Corn Belt	-3,600	5,185	-1,696	-14	0	-125	2,205
Western Corn Belt	-2,000	4,400	-2,850	-630	135	-945	4,484
Delta	505	-5,830	-165	48	365	-5,077	1,119
Southern Plains	800	-170	-1,905	-2,100	-2.246	-5,621	5,492
Central Plains	2,510	3,770	-4,901	-2,810	33	-1,398	5,660
Northern Plains	218	4,460	-3,822	-285	0	571	8,013
West	61	0	-915	-200	-1,019	-2,073	320
Pacific Northwest	27	0	-1,550	0	0	-1,523	2,281
Totals	-6,612	3,850	-17,974	-6,351	321	-26,766	31,433

Land Use – Total land in farms decreased during the 1980-1999 period. This decrease was primarily the result of urbanization, conversion for rural residences and recreation, and reversion of marginal land to forest. The decrease totaled 85 million acres, or 8 percent, with the rate of decline equal to 4.8 million acres per year. The vast majority of this land was not prime crop land and, thus, had only a small impact on crop acreage. In the next 20 years, urbanization and other uses are expected to continue to reduce land in farms at an increasing rate. This will also moderately reduce total crop area.

Acreage planted to principal crops declined from 357 million acres in 1980 to 330 million acres in 1999. Acreage was near a peak in the early 1980's as a result of rapid growth in export demand during the 1970's and the subsequent full production policy. The decline of 27 million acres, noted in table 1, has been the result of several factors. First, the CRP, a long-term conservation program, not in place in 1980 reached 31.4 million acres by 2000. Table 1 sorts out some of the acreage changes by region. The largest CRP acreage is in the three Plains regions, accounting for over 60 percent of the national acres. In the Southern Plains, the reduction in the five primary

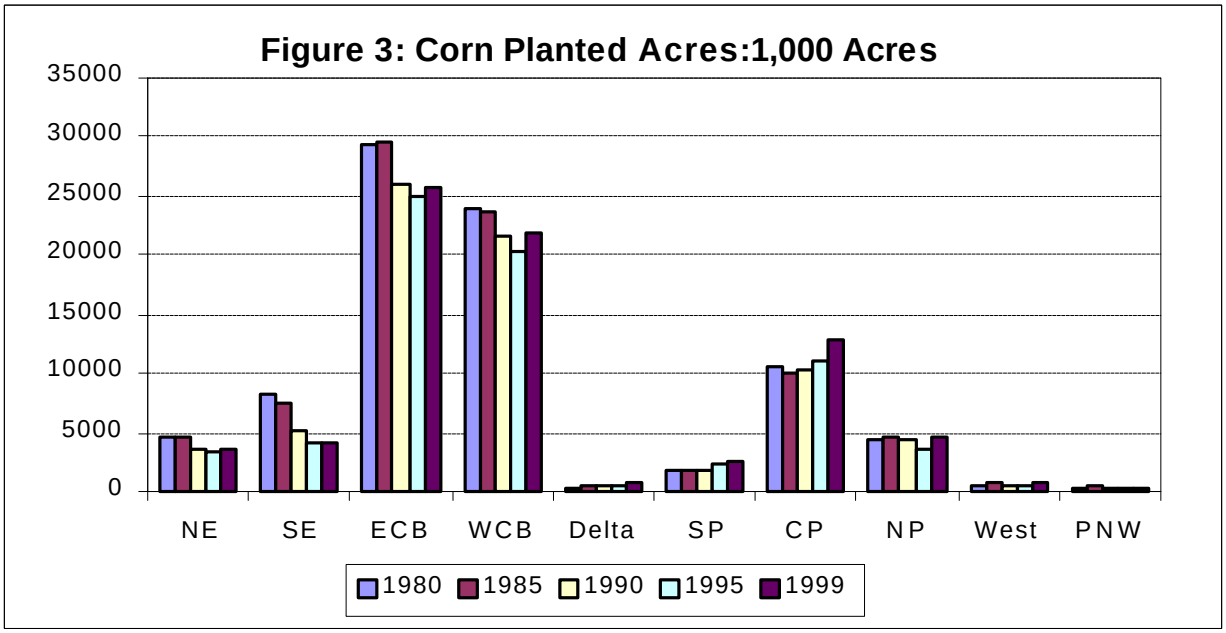


crops shown in table 1 is about equal to the increase in the CRP acres. However, a different pattern emerges on the Central and Northern Plains. On the Northern Plains, for example, 8 million acres is in the CRP, yet acres planted have increased. Moisture conservation inherent in minimum tillage has allowed many more acres to be continuously cropped rather than lying fallow every other year. Thus, changing technology is stimulating acres on the Central and Northern Plains.

A different picture emerges for the Southeast and the Delta, however. In these regions, acreage has been taken out of farms because of urbanization, rural residences, and reversion to forest and noncropping uses. In terms of the five principal crops (table 1), the Southeast has dropped planted acres by 10 million since 1980, and the Delta region by 5 million. This 15-million-acre decline in the two regions includes only 2.8 million CRP acres. Soybean seeding declined by 14 million acres in the two regions, a decline of 55 percent. Corn also declined by 3.7 million acres in the two regions. Cotton acreage increased by 3.4 million acres.

Irrigated land increased from 50 million acres in 1978 to 55 million in 1997, or 9 percent, (Census of Agriculture). The largest growth regions were in the Delta and the Central Plains, but irrigation expansion was also noted in the two Corn Belt regions. The increase in irrigated land represents only 1.5 percent of acreage in principal crops over nearly 20 years so, while it was a contributor to increased production, it has not been a major factor.

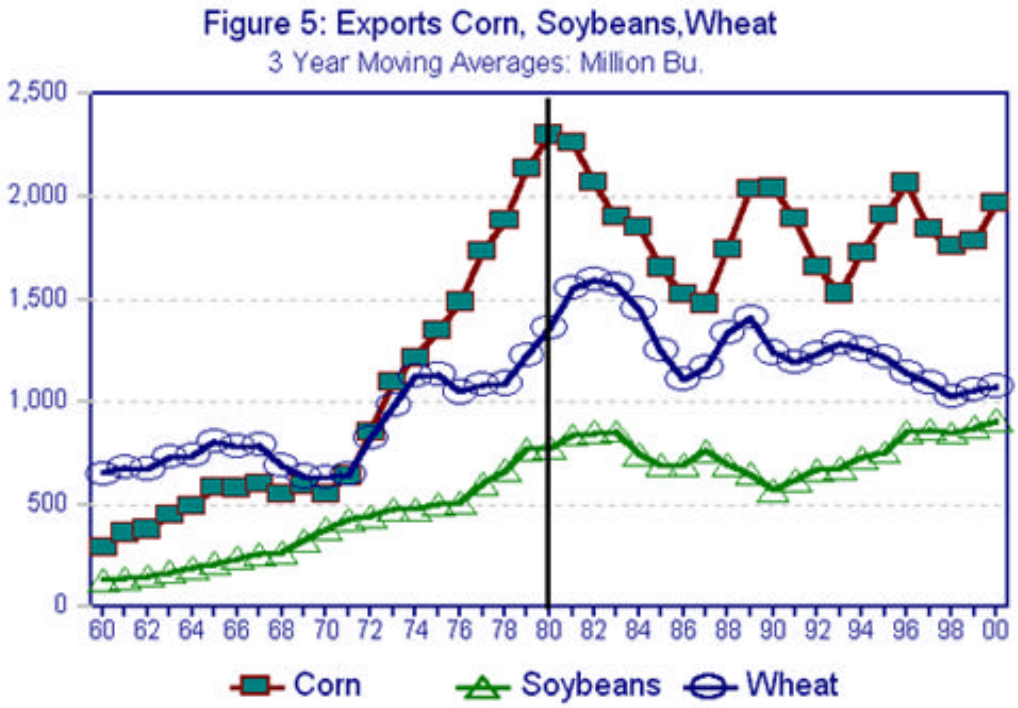
In terms of crop mix, acreage of major crops has declined with the exception of soybeans. Wheat acreage dropped the most, 18 million acres, from 80.8 million acres in 1980 to 62.8 million acres in 1999. As shown in figure 2, acreage declines were noted in all regions of the country but were greatest on the Plains and in the Western Corn Belt. The reasons for large losses of wheat acres



were more profitable corn and soybean alternatives and CRP acres. Finally, loan levels under the FAIR Act favored soybean production relative to corn or wheat, and planting flexibility enabled the shift.

Corn acreage declined by nearly 7 million acres, from 84 million acres to 77 million acres. The decline was most dramatic in both the Eastern and Western Corn Belt, as acreage in these areas shifted to soybeans. The Southeast also experienced declines of 4 million acres. As shown in figure 3, corn acreage increased on the Plains, as wheat acreage was dropping. While the Corn Belt remains the dominant producer, the traditional Corn Belt has grown farther to the west and northwest. This is a result of technological improvements in both genetics and the adoption of moisture-conserving minimum tillage and policy changes which no longer require planting of wheat base acres to receive government payments. As a result, the three Plains regions accounted for 26 percent of the Nation's corn acres in 1999, compared to only 20 percent in 1980. Soybeans gained the largest acreage during the 1980-1999 period, accounting for a 4-million-acre increase. As shown in figure 4, the Southeast and Delta regions both had sharp declines in soybean seedings, while the Corn Belt and Plains increased acreage. The shift to soybeans has been stimulated in recent years by the level of the soybean loan relative to the corn and wheat loans and by the agronomic advantages of having a 50-50 crop rotation in the Corn Belt for corn and soybeans.

Sorghum acreage has declined sharply, from 15.6 million acres in 1980 to 9.3 million acres. All regions reduced sorghum acreage during the period, but the vast majority of sorghum is grown on the Central and Southern Plains, which experienced the majority of the acreage reductions. Sorghum acreage has shifted primarily to corn.



Cotton acres ended the century at about the same level as in 1980 with 15 million planted acres, although acreage did drop to 10 million in the mid-1980's with slack export demand. Southern Plains acreage has dropped by about 2 million acres, with Western acreage down 1 million acres. These acres have shifted to the Southeast, which gained 3 million acres, and to the Delta with a gain of 1 million acres.

Thinking toward 2020, movement toward globalized markets means that the United States will shift grain and oilseed production in the direction of its greatest comparative advantage in production, processing, and transportation. This likely favors a continued reduction of wheat acreage. Soybean acreage will likely increase. The United States is a low-cost producer, if nonland costs are considered, and its modern transportation system has a significant advantage over that of its South American competitors, although the magnitude of that advantage is likely to decline. Soybean varieties have been adapted for successful introduction farther to the west and north, opening new opportunities for acreage expansion. Corn acreage will likely increase the most over the next 20 years, as the United States has a major advantage in variable production costs and a favorable climate for corn, which is not available in most regions of the world.

Grain and Soybean Exports – Exports of bulk grains and oilseeds are volatile, and perspective is important. Figure 5 shows corn, soybean, and wheat exports from 1960 to 2000 using 3-year moving averages, which reduce year-to-year fluctuations, enhancing the interpretation of the basic trends. The drama of the 1970's cannot be overlooked. When world demand surged, the United States initially had grain stocks to offer and then was able to move land into production rapidly to capture market share before other countries could increase acreage.

Since the early 1980's was the peak in exports, trend analysis for the 1980-1999 period is misleading. Viewed in the broader context shown in figure 5, corn, soybeans, and wheat each have a unique pattern. Corn exports have roughly been sideways with wide fluctuations since the early 1980's. Soybeans declined in the 1980's but moved back to an uptrend in the 1990's. Wheat, on the other hand, has remained in an overall downtrend.

Combining all grains, the total volume of grain and oilseed exports peaked in 1980-1981 and has erratically moved lower since. In 1981, grain and oilseed exports reached 131 million metric tons and were 109 million metric tons in 1999. The major reasons for this decline are increased world production, declines in agricultural exports to Western Europe and the Former Soviet Union, and a shift in emphasis from bulk grain and oilseed shipments to more highly processed food exports including animal products. By major commodity, corn export volume was down 18 percent from the near-record levels in 1980. Wheat exports have dropped 21 percent in volume since 1980, sorghum by 28 percent, and barley by 54 percent. In contrast to wheat and feed grains, soybean exports were up 6 percent.

Changes in export destinations have had profound impacts on individual port activity. Only two areas have maintained or increased their total volume of grain and oilseed activity. The Mississippi River ports increased from 51 to 61 million metric tons during the 1980-1999 period, and the Pacific Northwest ports have increased from 19 to 20 million metric tons. The importance of these two export regions has grown as other ports have declined or become inactive for grain and oilseed shipments. In 1980, Mississippi River and Pacific Northwest ports accounted for 53 percent of out shipments. By 1999, that dominance was 74 percent.
At other ports, activity dropped sharply between 1980 and 1999. The third largest port region is North Texas where export activity dropped by 41 percent, from 21 million metric tons to about 12. Lakes ports, the next most important, have dropped 44 percent, from about 12 million metric tons to about 7. Atlantic ports have virtually become unused for grain and oilseed shipments. In 1980, about 14 million metric tons were shipped from Atlantic ports. By 1999, that volume had dropped to 1 million, a decrease of 90 percent.

Corn exports out of the Mississippi River ports have grown, as have those out of the Pacific Northwest, to a lesser extent. Soybean exports out of the Mississippi River ports have grown, and those from the Pacific Northwest have experienced modest growth. Wheat exports have declined sharply from North Texas ports, remained more stable from Mississippi River ports, and been stable to slightly increasing out of Pacific Northwest ports.

Growing Importance of Domestic Use – The growth market for grains and soybeans has been domestic. Since the surge in grain and oilseed exports from 1972 to 1981, domestic use has become a significantly greater percentage of total use. For corn, as an example, domestic use as a percentage of total use has increased from 67 percent of the 1980 crop to 80 percent of the 1999 crop. For wheat, the portion used domestically has increased from 34 percent to 54 percent and from 61 percent to 64 percent for soybeans. In terms of total bushels, domestic use increased

about 2.7 billion bushels for corn, 600 million bushels for soybeans, and 500 million bushels for wheat.

It is important to point out that part of this domestic growth results from increased exports of animal products. Rapid growth in livestock and poultry product exports has increased domestic feed use. Our rough estimate is that corn use for animal products destined for export markets may have increased corn use by about 600 million bushels in 1999 compared to 1980. Soybean meal and other feed proteins benefitted also. Exports of soybean meal and oil were also increasing slightly during his period, which, if the raw bean equivalent were added to bulk soybean exports, would modestly increase the growth rate of the combined soybean/ soybean-product exports. Thus, if the derived export impacts of further processed agricultural commodities are considered, a more optimistic view of export growth emerges.

Grain Processing – Consolidation of processing firms has reduced the number of firms to the point that USDA's National Agriculture Statistics Service (NASS) and the U.S. Census Bureau data are no longer available for States in a number of cases. Thus, data from other sources must be used for processing locations. For example, the 1997 Census of Manufactures data for soybean processing contain data for only 5 States, and for 12, including Iowa, a "D" is recorded, indicating that the number of firms was too small to avoid disclosure. Location of processing is primarily dependent upon relative transportation rates, characteristics of the products, product user location, relative processing costs, and tradition. However, most grain and oilseed processing is and will remain raw-material oriented.

Corn used for processing into food and industrial products increased from 639 million bushels in 1980/81 (8.8 percent of total disappearance) to 1,826 million bushels in 1998/99 (19.6 percent of total disappearance). The largest percentage growth from 1980/81 to 1999/00 has been for high fructose corn syrup (HFCS) and fuel alcohol. Use for HFCS increased at an average annual rate of 6.7 percent, 15.7 percent for fuel alcohol. Growth for both was lower in the 1990's. Future use of corn for fuel alcohol depends substantially on actions under the Clean Air Act. Phasing out methyl tertiary butyl ether (MTBE) and maintaining oxygenation requirements for reformulated gasoline would nearly double the use of ethanol from 1999 to 2004, the end of an assumed phase in period (USDA, "Replacing MTBE with Ethanol"). According to the Renewable Fuels Association, current capacity for fuel alcohol production is 1,868 million gallons per year, with 119 million under construction and 690 million "under development." Alcohol plants, existing and planned, are located primarily in the Western Corn Belt, and the Central and Northern Plains.

Whether or not capacity is built is the difference between what would be a slowing growth rate or a near-term doubling, and it depends on imminent policy decisions. Even the lower rate depends on continued national ethanol fuel incentives. HFCS growth is also expected to slow. Without the added ethanol demand, food and industrial use will likely increase about 2 percent per year to about 2,870 million bushes by 2020. Use of corn as feedstock for plastics, now technically feasible and in commercial production, could add a whole new dimension of industrial use. With the exception of use for beverage alcohol and cereal, the location of food and industrial plants will tend to be raw-material oriented.

Markets for soybean meal are livestock oriented, and markets for oil are population oriented. Export volumes of meal and oil are also not in proportion to their relative yields from soybeans. Thus, soybean processing will continue to be done in areas of soybean production, and a portion of the crop will continue to be exported as oil and meal. Domestic crush has accounted for a relatively constant percent of total soybean disappearance since 1990, which has averaged about 61 percent. Domestic use of soybean oil has increased at a 3-percent annual rate over the 1980-1999 period. Increased use of other oils as well as some evidence of lower use of total fats and oils per capita suggest a lower rate of increase in the future. These data suggest increased use of soybean oil no higher than the rate of population increase and somewhat lower than USDA and FAPRI baseline estimates. This implies greater growth of oil exports relative to meal exports.

Wheat milling has traditionally been somewhat more product-market oriented than corn and soybeans. The pattern of wheat milling also reflects the dispersion of wheat production and variation of types. Domestic use of wheat for food has been increasing faster than population. Wheat milling is likely to increase only slightly faster than the rate of population growth between now and 2020.

Grain Exports Expansion to 2020 – The volume of grain and soybean exports in 2020 will be determined by a wide range of events that cannot be accurately forecast. However, what can be done is to establish a set of assumptions and look at the implication of export volumes if those assumptions should hold. This provides a baseline from which discussion can occur. Estimates are given for the three major grains: corn, soybeans, and wheat. Acreage planted to each crop is assumed to be at the levels used by the USDA baseline and FAPRI models for the year 2009, averaging individual crop acreage in the two models. Both models assume that the CRP will remain near or at its current authorized maximum of 36.4 million acres and that U.S. policy will remain similar to current policy. This means government would not manage crop acreage other than the CRP and it would continue in a full production mode. Yields in 2020 are assumed to be linear trends of actual U.S. yields from 1980 to 1999. Total production of corn would rise to 12.6 billion bushels, a 33-percent increase. Soybean production would rise to 3.7 billion bushels, a 39-percent rise. Wheat production would increase to 2.9 billion bushels, a 25-percent increase. The much smaller rate of increase in wheat is a result of slower yield gains in the 1980-1999 base period.

Domestic use is estimated for major categories from various sources of information and analysis. Feed use is based upon expected growth in livestock and poultry production. Industrial use is based upon trend analysis and subjective evaluations.

Exports are calculated as a residual once domestic use is deducted from production. This means that the United States would stay in full production status, except for the CRP, and what is not consumed domestically will be exported. This approach is based on the belief that variable costs of production in the United States are competitive. Defense of land values and rents is a matter of policy and the sums Government is willing to spend. Support of land values through price supports and production restriction would sacrifice the export market, an undesirable result. Thus, it is assumed that land will stay in production and that farm income deficiencies will be

made up by the Federal Government. Lower prices will not take much land out of production. These assumptions imply that prices in the export market will be allowed to move to whatever levels are needed to clear the market, and Government policy will not restrict production. Given these assumptions, bulk shipments of corn would increase by 50 percent, soybeans by 54 percent, and wheat by 19 percent. Measured in total bushels, the export volume of the three major commodities would increase by 42 percent, (table 2). Certainly there are other courses that U.S. policy could, and may, take. These alternative courses could result in substantially different outcomes.

Animal Agriculture - 1980-2020

Chicken Growth – Domestic demand for chicken has increased dramatically since the beginning of the broiler industry. Cost reduction, product innovation, and healthy image have set a pace to take chicken to first place among the meats (boneless weight) in the U.S. diet by 2010. Total production has increased at a greater rate than consumption because of increased exports and a shift in tonnage of the least desired parts to pet food and rendering. The number produced increased at an average rate of 3.7 percent per year from 1980 to 1999. Pounds produced increased 5.2 percent per year, and per capita consumption increased at a 2.8-percent annual rate. No doubt, there is a limit to the appetite for chicken that will likely be reached before 2020. There are signs of a lower rate of increase in 2000. The USDA baseline estimate shows an increase to 95.4 pounds (retail weight) in 2009. This estimate, consistent with a total red meat and poultry consumption of 222.8 pounds per capita, seems optimistic for 2010 but reasonable for 2020. A population of 322.7 million and retail weight consumption of 95.4 implies slaughter weight of 34.9 billion pounds for the domestic young chicken market by 2020.

Broiler meat exports recently accounted for about 17 percent of U.S. production. Much of that is composed of parts (mainly leg quarters) not favored by U.S. consumers. Major importers are China (mainland and Hong Kong), Japan, Mexico, Russia, and Saudi Arabia. There is no room for more chicken production in Japan and Hong Kong. Russia's economy is expected to improve, and it will produce more of its own. Mexico can produce chicken but not at U.S. leg quarter prices. Wide open markets and U.S. imports of white meat would allow increased trade and more equal parts prices. East Asian neighbors may supply some of the increased demand by Japan and Taiwan using imported feed ingredients. USDA's baseline shows an increase in broiler exports of 31.4 percent from 1999 to 2009. FAPRI projects a 55-percent increase for the same period, a gain in world export share. These may both be on the optimistic side. The working figure used in this study is 7 billion pounds for 2020, a 44-percent increase. Thus, total U.S. production would reach 41.9 billion pounds in 2020, a 43-percent increase from 1999.

Broiler production is concentrated in the Southeast and Delta regions with the Southern Plains gaining share. While these regions will continue to dominate, expansion of production in the Corn Belt is expected. Technology reduces the advantage of low-cost labor, and labor cost differentials have diminished. Housing costs in the South provide less advantage than was once

the case.

Turkey To Expand Exports – Turkey meat production increased at an average annual rate of 4.4 percent from 1980 to 1999, but the rate slowed to 1.7 percent from 1990 to 1999. Per capita domestic use of turkey appears to have stalled at about 18 pounds in the 1990's after dramatic increases in the 1980's. Domestic use of turkey can be expected to increase with population and require production of 5.8 billion pounds (carcass weight) by 2020. Exports of turkey expanded rapidly from about 50 million pounds in 1990 to over 600 million in 1997, then fell to under 400 million in 1999. USDA's baseline estimates take turkey exports to 900 million pounds in 2009, well ahead of FAPRI's 667 million. Both appear optimistic. This study uses a working figure of 700 million pounds for 2020. Total production is expected to reach 6.5 billion pounds in 2020, a 23-percent increase from 1999.

Turkey production increased rapidly in the Southeast from 1980 to the mid 1990's but has decreased since. Disease and environmental problems limited activity there. The modest expansion anticipated for the next two decades is likely to be feed-supply oriented. Thus, some expansion in the Corn Belt regions is more likely than in the Southeast. In the West, turkey production is expected to remain near 1999 levels, as population pressures discourage expansion.

Shifts in Egg Production – Egg demand shows definite signs of recovery from a long-term decline beginning in 1990. A much-diminished public concern about dietary cholesterol and increased eating of breakfast away from home have benefitted eggs. Extending such a recently established trend is questionable, especially because much of the last 2 years' increase in use is supply induced at unsustainably low prices. Nevertheless, per capita use is projected for 2009 by FAPRI and USDA at 268 and 263.2 eggs respectively. There is little basis for projecting a further increase after 2009. An estimated 265 eggs per person in 2020 would result in annual domestic use of 85.5 billion eggs.

Long term export growth of shell eggs is limited to nearby, low-volume destinations because of unfavorable freight rates relative to feed. Hatching eggs and egg products export volume may increase somewhat. The shell equivalent of all eggs and egg products exported is estimated to reach 2.7 billion eggs by 2020, about 3 percent of table egg production plus hatching egg production for export. Total egg production to meet these demands is 88.2 billion in 2020, a 23-percent increase from 1999.

The location of egg production has shifted substantially from 1980 to1999. The Northeast, Southeast, Delta, and West regions lost share to both the Eastern and Western Corn Belts and the Central Plains. It is expected that production will remain near the demand point because of the relative cost of feed and egg transportation. However, the Corn Belt, as the lowest cost producing area, has the flexibility to supply any other region with shell eggs and is the region of choice for eggs for processing. Competition for space with people limits production in the Northeast and West (California) regions. Further concentration in the Corn Belt is likely by 2020.

Poultry Exports or Grain Exports – Poultry production and processing technology are

transferrable. The market for poultry genetics and equipment is global, yet U.S. operations (even under foreign ownership) appear to excel with respect to production efficiency. Learning in the former Soviet Union, Central Europe, and developing countries will diminish this advantage. If (when) the organizational differential is diminished, the feed versus product transport cost will determine whether the U.S. exports feed as feed or as poultry products.

Product transport is expensive relative to bulk feed ingredients. Refrigerated container rates for frozen poultry from Atlantic or Gulf ports to Hong Kong were reported at $ 148+ and to Japan at $183+ per metric ton in June 2000 (USDA, Agricultural Marketing Service). Grain rates to Japan were reported at $10.71 from Pacific Northwest ports and $19.46 from the Gulf. Feed conversion for shell eggs is about 2.7:1 and for liquid egg products about 3.2. Freight rates do not favor eggs, given equal production performance, except for dried products. Broiler feed-to-ready-to-cook conversion is roughly 3 and about 3.25 for turkey including feed for breeders. Other things being equal, ocean freight favors shipping feed over poultry products.

Slow Beef Growth – The number of beef cows dropped by 9 percent during the 1980-1999 period. This was the result of declining demand for beef and strong increases in productivity per cow. Beef cows remain the most widely dispersed segment of major animal production, with the industry having some importance in all regions. The largest decrease in cow numbers was in the Western Corn Belt, the Eastern Corn Belt, and the Delta regions. Cow numbers were stable to increasing in the three Plains regions. In 1980, the Plains States accounted for 47 percent of the beef cows but increased to 52 percent by 1999. In contrast, the Corn Belt States dropped from 22 percent of the cows to only 14 percent by 1999.

Cattle feeding became increasingly concentrated in the center of the country, particularly the Central and Southern Plains. Notably, cattle on-feed in the Western and Eastern Corn Belts decreased. In addition, activity in the Western region also dropped as on-feed numbers moved farther to the East. The geographic concentration in the Central and Southern Plains increased dramatically from 53 percent of the cattle on-feed in 1980 to 67 percent in 1999. In contrast, Corn Belt feeding dropped from 25 percent of the Nation's total to 18 percent, with the West dropping from 10 percent to 5 percent. The total number of head on-feed increased from 12 to 13 million head.

Brood cows remain the one segment of animal production which has lagged in terms of industrialization. This is because brood cows are economically best adapted as extensive forage grazers and, thus, have not been concentrated into dry lots where more intensive industrialized practices become economical. There is no technology on the horizon which is likely to allow the brood cow segment of the beef industry to be able to apply industrialized principles as long as vast amounts of grazing land are available at low land rents throughout the country. This implies that brood cows will tend to be held by many producers in relatively small herds and that the industry will remain relatively disaggregated, lacking consistency in genetics, management practices, and qualitative factors. Thus, the beef industry will continue to lose ground to poultry and pork in terms of economic efficiency, innovation, meat quality consistency, and, ultimately, consumer demand.

Consumer preferences have shifted away from beef during the past 20 years as per capita consumption has dropped from 76.5 pounds to 69 pounds in 1999. The USDA baseline suggests a further decline in beef consumption of 17 percent to 57 pounds in 2009. However, this study uses a 10-percent erosion over the next 20 years to 62 pounds. Beef exports are expected to grow as transportation economics favor foreign shipments of high-value beef products over shipment of feed to foreign markets. A 40-percent increase in beef exports over the next 20 years with constant import is assumed for the purposes of this study. These numbers imply that total beef production would reach 29.1 billion pounds by 2020, representing only a 10-percent increase from 1999.

Thus, the beef sector is expected to experience slow growth with the most optimistic segment being the export market. Emphasis within the industry will be on improving coordination among the many small brood cow producers and the multiple segments of the industry (brood cows, backgrounding, cattle feeding, and processing). The movement to improved coordination is expected to come more slowly than for pork, dairy, and poultry. Greater concentration of the beef industry is expected as more of the brood cows shift slowly to the center of the country where the Plains are expected to continue to grow in importance. Productivity per cow will continue to increase at the rate of about 1.6 percent per year, which will far exceed the .4 percent increase in aggregate demand. As a result, brood cow numbers could drop by 20 to 25 percent by 2020. The feeding and processing segment will become more concentrated in the Central and Southern Plains.

Dairy – Milk cow numbers dropped 15 percent as a result of sharp increases in productivity per cow over the period from 1980 to 1999. Three regions had increases in milk cow numbers in the face of sharp reductions in the country as a whole. These were the West, the Southern Plains, and the Pacific Northwest. Sharp reductions in numbers occurred in the Eastern Corn Belt, the Western Corn Belt, the Southeast, and, to a lesser extent, the Northeast. Industrialized dairies in the West and Southern Plains have well above average productivity, thus their importance in milk production grew even more than their increase in cow numbers. Production of milk in the West, for example, was 12 percent of the Nation's production in 1980 but 22 percent by 1999. The same numbers for the Pacific Northwest were 5 percent and 8 percent and in the Southern Plains 4 percent and 7 percent. In contrast, milk production in the two Corn Belt regions was 41 percent in 1980, dropping to 32 percent in 1999.

Conversions to more industrialized production are dramatically altering the industry. Traditional dairy production was on smaller scale family farms where the cows grazed during the months of vegetative growth. The industrialized dairy model involves dry lots, with all feed brought to the cows. In the Western model, the industrialized dairy operation often involves a relatively small land base with feed purchased from other local farmers and arrangements for manure disposal also arranged with them. The industrial dairy concentrates large numbers of cows in standardized systems and employs intensive management resulting in high productivity. As a result, the number of farms with milk cows dropped by two-thirds, from 334,180 farms in 1980 to 111,220 farms in 1999.

In the past 2 years, industrialized milk production operations have been developing in traditional regions of the country, especially the Corn Belt. These are driven by changes in the Federal milk marketing order, which will serve to reduce milk prices in locations distant from Wisconsin (such as Florida), as well as the desire to locate near abundant and low-priced feed supplies. The growth in processed milk products will tend to come from industrialized dairies near feed-abundant production. These drivers are expected to result in some recovery in Corn Belt milk production. Population increases will be a primary driver of the production location for fluid consumption. It is assumed that dehydration and reconstitution of milk does not grow and that fluid production will remain near the population. The West region is expected to add nearly 15 million people by 2020, a 35-percent increase from 1999. This means that production expansion will continue in that region but be located farther from the population centers than in the past, including continued expansion of milk production in the Pacific Northwest.

Population in the Southeast is expected to grow by about 12 million people, or 21 percent, by 2020. As industrialized dairies return to the Midwest, it is likely some of this population growth will be supplied from feed-abundant areas in the Eastern Corn Belt. While feed prices will be lower in the Western Corn Belt, limited population growth and costs of transporting milk will limit growth there.

The third major population growth region will be the Southern Plains where population is expected to increase by 7 million in 2020. This growth will be supplied by increased production in the Southern Plains and somewhat in the grain-abundant Central Plains. Productivity per cow will likely accelerate in the 2000-2010 period as industrialized milk production becomes the norm. However, after 2010, industrialization of the U.S. industry is expected to be nearly complete, and a slower rate of productivity growth is expected. Total milk production may increase to 205 billion pounds, an increase of 26 percent from 1999, reflecting a slight increase (.3 percent) in annual per capita consumption. Cow numbers would fall from 9.2 million in 1999 to about 8 million in 2020, a decrease of 13 percent.

Pork To Complete Industrialization – Hog inventories were near all-time highs in 1980 and have declined by 12 percent since. The breeding herd has declined even more sharply by 35 percent. This sharp decrease is partially a result of the unusually high inventory in 1980 but, more importantly, is due to huge increases in sow productivity. As with the dairy industry, industrialization has greatly altered the structure of the industry.

Major regional changes have taken place as well. The importance of the Corn Belt as the center of the breeding herd has declined. In 1980, the two Corn Belt regions accounted for 63 percent of the total breeding herd, down to 53 percent in 1999. The breeding herd shifted to the Southeast and the Central and Southern Plains. These three regions accounted for 28 percent of the breeding herd in 1980 and 38 percent in 1999. While the Western Corn Belt's breeding herd importance has declined, it has maintained its relative importance in terms of the market herd. The Western Corn Belt has had sow reductions but has greatly increased importation of pigs farrowed in the Central Plains. Thus, hog finishing has grown even as the importance of breeding animals was decreasing.

The major driver of change in the pork industry in the past 20 years has been the application of industrial principles involving large-scale production units with standardized production processes. This led to the advent of "megafarms" with more than 50,000 sows in the operation. This movement has driven costs lower and increased product quality. As a result, the number of hog farms declined by an astounding 85 percent, dropping from 670,000 in 1980 to just 98,460 in 1999.

Another result of the industrial process has been the movement to much greater coordination of production and slaughter. The enhanced coordination took place in all segments of the industry, including those between input suppliers and producers; between the production segments of farrowing, nursery, and finishing; and between producers and packers. The rise of vertical integration in the industry was a primary driver as these operations coordinated the entire pork system from input supplies to final meat products. The economic advantages gained by integrators forced other segments of the industry to increase their degree of coordination to better compete with integrators. These included mega producers closely aligning with packers, as well as the remaining smaller independent producers combining their resources in cooperatives and other types of alliances to remain competitive. The mechanism used to increase coordination among nonintegrated operations was production and marketing contracts. In early 2000, marketing contracts or internal transfers were used by 75 percent of the industry to coordinate movement of animals between producers and packers (Grimes and Meyer).

The transition to industrialization has been ongoing in the pork industry for over 10 years. It is likely that this evolution may now be 70-80 percent completed. This means that the last 20-30 percent of the movement will be occurring between 2000 and 2005. Once this transition is complete, the rate of structural change will slow. The emphasis has already shifted to forming highly coordinated pork systems with three basic models: total vertical integration, cooperative, and coordinated independent producers and packers. Only 8-10 of these pork systems are expected to emerge. Between 2010 and 2015 international pork systems are expected to predominate with coordination and competition on a global scale.

Domestic pork demand edged lower during the past 20 years. However, the decline was not as strong as for beef. In the past 15 years, the trend in per capita consumption has been fairly flat. Both FAPRI and USDA expect to see per capita consumption drop modestly in the coming decade to about 51 pounds, which will be used for 2020. Exports are expected to grow by 127 percent during the next 20 years, while imports remain near current levels. This means that total production would reach 23.3 billion pounds, a 21-percent increase from 1999. Sow productivity has been growing at a remarkably high rate of nearly 3 percent per year. This rate will likely be reduced to closer to 1.5 percent per year over the next 20 years. This means that sow productivity growth will more than keep up with aggregate demand growth and that breeding herd numbers will drop about 15 percent from 6.5 million in 1999 to 5.5 million in 2020.

Growing Importance of Animal Product Exports – An important contributor to increased domestic grain use has been the increase in feed use for animal product exports. In 1999, exports of chicken, beef, pork, and turkey totaled 8.9 billion pounds, compared with only 1.1 billion

pounds in 1980, representing an eightfold increase. By species, the increase in tonnage exported from 1980 to 1999 was: beef 1354 percent; chicken, 778 percent; turkey, 479 percent; and pork, 406 percent. Obviously, these levels of increase can only be attained because exports were at such a low level in 1980. Meat and poultry exports were one of the bright growth areas of the past 20 years. As a portion of domestic production, exports now represent the following percentages: chicken, 17 percent; beef, 9 percent; turkey, 8 percent; and pork, 7 percent. Chicken exports include a large volume of lower valued parts, while pork and beef exports are high-valued cuts destined for the Asian market.

Agricultural Shipments in 2020

Results of the study are shown in table 2. Commodity export volume of major grains is likely to grow by 42 percent. This is weighted heavily toward additional corn and soybean volume. The large increase is based upon a full production policy in the United States. (less CRP acreage at 36 million acres). Production volume will increase most in the Western Corn Belt and the Central and Northern Plains areas that are the farthest from export markets.

Domestic use of grains and soybeans is expected to increase by 28 percent. This will be led by growth in domestic corn use of 30 percent as a result of growth in feeding use (23 percent) and especially industrial use (51 percent). Soybean crush would increase 28 percent with growth in domestic feeding and growing exports of animal products. Domestic wheat use is expected to increase 20 percent, only slightly above the rate of population increase.

Production of meat and poultry is likely to grow by 26 percent. This will be led by growth in chicken production (43 percent) and milk production (26 percent). Turkey (up 23 percent) and pork (up 21 percent) are expected to increase at near the population growth rate. Beef is expected to lag with a growth of only 10 percent. Per capita consumption is expected to continue to grow for chicken, remain constant for turkey, decline moderately for pork, and drop for beef.

The fastest growth for meat and poultry products is expected to be in the export market. Increases are likely to be as follows: chicken, 44 percent; turkey, 85 percent; beef, 40 percent; and pork ,127 percent. Other than for pork, these rates of export growth are more conservative than suggested by either USDA or FAPRI models.

Table 2: U.S. production and utilization - 1999 to 2020 by major category

Commodity	Unit for volume	1999	2020	Change in volume	Change in percent
		Animal industries			
Meat and poultry:					
Eggs	Billion eggs	71.8	88.2	16.4	22.9
Turkey	Billion lbs.	5.3	6.5	1.2	22.6

Chicken	Billion lbs.	29.4	41.9	12.6	42.7
Ducks	Billion lbs.	.11	.13	0.02	20.9
Beef	Billion lbs.	26.4	29.1	2.7	10.1
Pork	Billion lbs.	19.3	23.3	4.0	20.9
Dairy	Billion lbs.	162.7	205.0	42.3	26.0
Total	Billion lbs.	80.4	100.9	20.5	25.5
		Major crops			
Corn:					
Production	Million bushels	9,437	12,590	3,153	33.4
Feed	Million bushels	5,625	6,890	1,265	22.5
Industrial	Million bushels	1,920	2,890	970	50.5
Exports	Million bushels	1,875	2,810	935	49.9
Total	Million bushels	9,420	12,590	3,170	33.7
Soybeans:					
Production	Million bushels	2,643	3,660	1,017	38.5
Crush	Million bushels	1,570	2,012	442	28.2
Seed	Million bushels	170	170	0	0.0
Exports	Million bushels	965	1,488	523	54.2
Total	Million bushels	2,705	3,670	965	35.7
Wheat:					
Production	Million bushels	2,302	2,880	578	25.1
Imports	Million bushels	94	100	6	6.4
Food	Million bushels	920	1,115	195	21.2
Feed	Million bushels	396	485	89	22.5
Seed	Million bushels	90	87	(3)	-3.3
Exports	Million bushels	1,090	1,293	203	18.6
Total	Million bushels	2,496	2,980	484	19.4
Bulk grain & soybeans exports:					
Corn	Million bushels	1,875	2,810	935	49.9
Soybeans	Million bushels	965	1,488	523	54.2
Wheat	Million bushels	1,090	1,293	203	18.6
Total	Million bushels	3,930	5,591	1,661	42.3
Domestic use:					
Corn	Million bushels	7,545	9,780	2,235	29.6
Soybeans	Million bushels	1,740	2,182	442	25.4
Wheat	Million bushels	1,406	1,687	281	20.0
Total	Million bushels	10,691	13,649	2,958	27.7

The Southeast region is expected to decline in relative importance for broilers, turkeys, eggs, and hogs. Delaware/Maryland/Virginia broiler production will decline. Broiler, turkey, and egg production will shift in the direction of the Eastern and Western Corn Belts. Hog production will shift in the direction of the Western Corn Belt and the Central and Southern Plains. Beef cows and cattle feeding will become even more concentrated in the Plains region.

Grain and oilseed export markets will grow in Asia but not to traditional buyers, Japan and

Taiwan. Each of these have severe land constraints and will have static or declining livestock production. Exports to South Korea will grow for both feed inputs and animal products. Other countries, such as Indonesia, Malaysia, and Thailand, will become growth markets for grain and soybean/soybean meal exports, and they, in turn, will help supply Japan's large animal product demand. China is expected to increase both grain, oilseed, and poultry imports. Mexico and Latin America will increase grain and soybean/soybean meal imports. North Africa and the Middle East will increase corn and wheat use. However, some of the wheat for this market is likely to come from increased production in Eastern Europe, the former Soviet Union, and the European Union. The largest increases of U.S. exports of grain and oilseeds should be to Asia, then to Mexico and Latin America, with the least increase going to Europe and Africa.

The largest growth markets for beef will include Japan, South Korea, and Mexico. The markets for pork, which are expected to grow the most, are Japan, Hong Kong, Mexico, and Russia. Growing poultry markets are expected to be China, Hong Kong, Japan, and the Middle East.

Implications for U.S. Transportation Needs and Policy

1. Commercial farm size will continue to grow. Consolidation will continue in grain elevators and grain processors. Fewer farmers and assembly points will result. The growth in farmers hauling directly to a processing, river export subterminal, or final feeding location will increase with the use of semitrailer trucks, thus bypassing local assembly points. This will continue to reduce the need for rural rail feeder lines in many areas, while growing bulk exports imply increased traffic on some mainlines, especially in regions where corn is displacing wheat acres. The need for transportation policy to determine which lines will be maintained will be critical. Decisions will be needed on which rural roads and bridges to maintain. Abandonment of some secondary rural roads should be expected in regions such as the Northern and Central Plains where population continues to drop. Planning and policy formulation should take an active role in making these determinations. In the Eastern Corn Belt, Southeast, and Southern Plains, the number of rural residents will likely increase; thus, rural roads and bridges will be maintained for reasons other than agriculture. Regional differences mean that planning and policy formulation will need to be localized.

2. The Southeast will see declines in its share of national poultry, dairy, and hog production. Poultry and dairy production are expected to have relative shifts toward the Eastern and Western Corn Belt regions. Livestock production will locate somewhere between the feed supply and consumption centers. Production in excess of local use is likely to be economically feasible only at the feed-producing end of the chain. Thus, shipment of feed to the Southeast for chicken or pork to use in New York or Chicago is less likely in the future. Hog production is expected to shift in the direction of the Western Corn Belt and the Central and Southern Plains. The largest interregional rail corn shipments are currently from the Eastern Corn Belt to the Southeast. This movement will lose relative market share in the next 20 years. Movement in the Eastern Corn Belt will be increasingly dominated by truck shipments.

3. The largest increases in bulk grain shipments are expected to be destined for Asia, Mexico,

North Africa, and the Middle East; thus, the largest growth in port activity is expected for the Mississippi Gulf ports. Expansion would also be expected for the Pacific Northwest ports, especially for corn and soybean loadings, and for high-quality wheat such as white and hard red spring wheat destined for Asia. Lakes ports could have some increased activity, but Atlantic ports would likely continue to be little utilized for grains or oilseeds.

4. There will be growth in corn and soybean production in the Eastern Corn Belt. The Eastern Corn Belt (and portions of the Western Corn Belt) with access to the Mississippi, Illinois, and Ohio rivers is expected to gain a larger portion of the export growth . The poultry and dairy industries are also expected to grow in the Eastern Corn Belt, along with some grain processing. Transportation implications include increased use of waterborne export facilities, locks and dams, barges, and tugs and increased activity at Mississippi River ports. As mentioned above, Eastern Corn Belt rail shipments to the Southeast may not grow and will drop going to the Northeast.

5. The largest bushel volume growth of grain and oilseeds will occur in the Western Corn Belt, the Central Plains, and the Northern Plains. Continued shifts toward more corn and soybeans at the expense of wheat, along with increased yields on vast acreage are the reasons. The relative growth in feeding and processing is expected to be greater than the rate of growth in exporting. The largest increases in feeding and processing could occur in these regions. Some added poultry, but especially beef cattle, and hogs are expected to concentrate there. The region provides low-cost feed, abundant land, moderate-cost processing locations, and flexibility for shipping animal and grain products in multiple directions to domestic populations in the East, South, and West.

6. Corn and soybean processing will be strong growth markets. Wheat milling will grow at much slower rates, which will be close to the rate of population growth. Corn and soybean processing is expected to grow the most in the Western Corn Belt and the Central and Northern Plains. Of course, the potential for new industrial and consumer products produced from crops could greatly alter transportation requirements. If corn were to increasingly be used for fuel alcohol and plastics, as an example, domestic processing use would rise dramatically, especially in the Western Corn Belt and Central Plains. As a consequence, the domestic usage would grow with corresponding reductions in export shipments.

7. Tighter coordination of supply, processing, and marketing chains is likely. This may mean fewer ownership transfers of products. However, improved functioning of markets that apply information technology may result in greater use of market coordination. In either case, shipments into the processing centers will become dominated more by truck. If the outputs from processing have more specific attribute characteristics, it is likely that the use of trucks will also gain in importance relative to rail.

8. More tightly coordinated production/processing means that transportation services will become more regionally concentrated. Industrialized animal production and large-scale grain processing mean greater concentration of transportation services. Where these

production/processing centers are located, the need for transportation services could grow dramatically. On the other hand, areas without production/processing centers will see transportation needs decline.

9. Among the largest growth markets for transportation in percentage terms may be refrigerated containers for shipments of meat products to Asia. This growth would be led by the shifting of Japan, Taiwan, Hong Kong, and Korea to greater importation of animal products.

10. While the impacts of biotechnology are unclear, it is likely that one outcome is entirely new, enhanced-attribute products. Some would argue these will be designer food products. Many of these new products will require more specialized transportation equipment to maintain their special attributes. The implications for transportation are the need for identity preservation, unique transportation solutions, and specialized equipment. This also implies that transportation service providers who are flexible, innovative, and responsive to their customers will have advantages.

11. The information revolution should be a high industry and policy priority because it has the promise of substantially increasing transportation efficiency and, thus, reducing costs. This is true of bulk shipments in truck, rail, or barge. In addition, close working relationships between transportation suppliers and shippers will most quickly develop the unique transportation solutions required of more specialized food products. Perhaps the biggest gain in transportation efficiency will come from increased information flows where cross hauling, empty back hauls, and the poorly utilized equipment concerns inherent in the rail industry can be reduced.

12. Flows of agricultural products will increase with Canada and Mexico. Agriculture will increasingly become viewed as a North American industry as agricultural and other trade becomes more integrated. Transportation policies need to be harmonious, and consistency in regulations will be needed. The goal should be to enhance transportation efficiency within North America, allowing each region of North America to increase specialization and trade.

13. Just as NAFTA is helping to lead the way to more integrated agricultural economies in North America, the same can be said for global agriculture. The lessons learned in integrating transportation industries and policies in North America will provide a foundation for expansion to more integrated transportation systems worldwide. The United States can serve as an advocate for the integration of world transportation systems through research and policy, as well as by example.

14. Long-term transportation policy is more difficult to formulate given the uncertainty in long-term U.S. agricultural policy. While U.S. policy has been favorable to stimulating bulk agricultural exports in the last 15 years, success has been more elusive. Current U.S. policy is based upon relatively full production. If the United States remains in a full production mode for the next 20 years, continued growth in exports can be expected as assumed in this analysis.

On the other hand, if U.S. policy reverts to production controls, the United States will likely lose world market share, and the required growth in transportation capacity for export markets of bulk commodities could be considerably smaller than suggested here.

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